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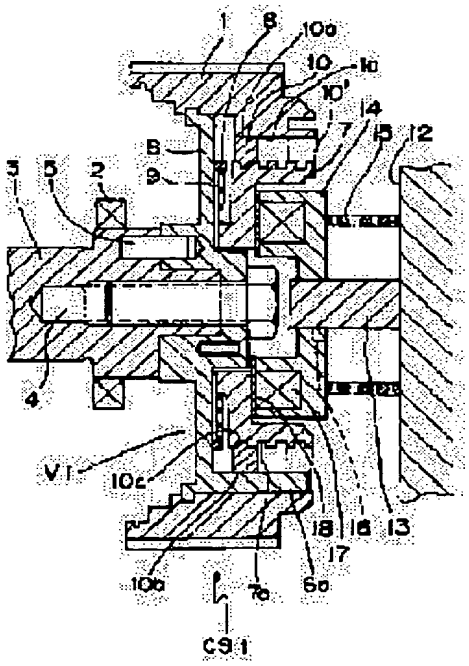
(54) VARIABLE VALVE TIMING DEVICE OF ENGINE



(57)Abstract:

PURPOSE: To provide a variable valve timing device of electromagnetic type, which can reduce wear of the friction engaging surface of a braking member while secures the braking force on a drum sufficiently.

CONSTITUTION: A variable valve timing device of electromagnetic type fitted with an advancing plate 10, drum 7, and braking member 14 transmits the torque of a cam pulley 1 to a cam shaft 3 and varies its rotational phase. At the time of normal brake application, a force in the opposite direction to the drum 7 side is applied to the braking member 14 using a coil spring 15 or a second solenoid, and the ratio of the friction braking force to the electromagnetic braking force is lessened, to reduce wear of a friction engaging member 18.

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[Claim(s)]

[Claim 1] The phase modification member which transmits the turning effort of a mechanical component to a cam shaft and to which the rotation phase of a cam shaft is changed with the variation rate to the predetermined direction on the other hand, The drum member to which the variation rate of the above-mentioned phase modification member is made to carry out in the above-mentioned predetermined direction according to the applied damping force, In the adjustable valve timing equipment of the engine with which the braking member which applies the friction-damping force and the electromagnetic-damping force to the above-mentioned drum member when a coil energizes was prepared electromagnetism -- a coil -- having -- this -- electromagnetism -- When the drum member is regularly braked by the braking member Adjustable valve timing equipment of the engine characterized by establishing a friction-damping force reduction means to reduce the ratio to the electromagnetic-damping force of the friction-damping force rather than the time of braking transitionally after braking initiation.

[Claim 2] Adjustable valve timing equipment of the engine with which a friction-damping force reduction means is characterized by reducing the ratio to the electromagnetic-damping force of the friction-damping force by applying the force of an opposite direction to a braking member with a drum member side in the adjustable valve timing equipment of the engine indicated by claim 1.

[Claim 3] the elastic member to which a friction-damping force reduction means energizes a braking member to an opposite direction with a drum member side in the adjustable valve-timing equipment of the engine indicated by claim 2 -- it is -- electromagnetism -- the decrement of the friction-damping force by the above-mentioned elastic member compensates with the electromagnetic-damping force at the time of the energization to a coil -- as -- electromagnetism -- the adjustable valve-timing equipment of the engine characterized by to be established the voltage-adjustment means which raises the electrical potential difference impressed to a coil.

[Claim 4] the 2nd electromagnetism which applies the electromagnetic force of an opposite direction to a braking member with a drum member side in the adjustable valve timing equipment of the engine indicated by claim 2 when a friction-damping force reduction means energizes -- a coil -- it is -- this 2nd electromagnetism -- the adjustable valve timing equipment of the engine characterized by a coil energizing when the drum member is regularly braked by the braking member.

[Claim 5] In the adjustable valve timing equipment of the engine indicated by claim 1 The 1st braking section arranged at the periphery side of an opposed face with a drum member at a braking member, Coefficient of friction of the 2nd braking section is set up smaller than coefficient of friction of the 1st braking section. the 2nd braking section arranged at the core side of the above-mentioned opposed face prepares -- having -- this -- And adjustable valve timing equipment of the engine characterized by preparing the braking section operation system which operates the 2nd braking section so that the 2nd braking section may apply damping force to a drum member when a drum member is regularly braked by the 1st braking section.

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to engine adjustable valve timing equipment.

[0002]

[Description of the Prior Art] Generally, the valve gear which opens and closes an inlet valve or an exhaust valve to predetermined timing is prepared in an engine. And in the engine equipped with this valve gear, the optimal closing motion timing of an inlet valve or an exhaust valve changes according to engine operational status, for example, an engine load, and an engine speed. Then, the adjustable valve timing equipment to which the closing motion timing of an inlet valve or an exhaust valve is changed according to engine operational status is proposed variously.

[0003] And in the engine with which the cam shaft for inlet valves and the cam shaft for exhaust valves were prepared according to the individual, for example, a DOHC engine, the adjustable valve timing equipment to which it was made to change the closing motion timing of an inlet valve thru/or an exhaust valve is used abundantly by changing the rotation phase of the cam shaft for inlet valves thru/or the cam shaft for exhaust valves. as one of such the adjustable valve timing equipment -- electromagnetism -- the adjustable valve timing equipment using a coil is known conventionally (for example, refer to JP,63-162910,A and JP,2-102305,A).

[0004] such electromagnetism -- in the conventional adjustable valve timing equipment using a coil, the advancing plate which can usually be displaced in the direction of a cam-shaft axis between the cam pulley by which a rotation drive is carried out with a crankshaft, and the hub attached in the cam shaft is arranged, this advancing plate fits into the claw part of a cam pulley, and the claw part of a hub, and, fundamentally, a cam pulley, an

advancing plate, and a hub (cam shaft) really rotate it. Here, when the claw part of a hub inclines to the direction of an axis, and has fitted in with the advancing plate, therefore an advancing plate displaces in the direction of a cam-shaft axis, according to this amount of displacement, the rotation phase to the cam pulley of a hub (cam shaft) changes.

[0005] And an advancing plate and the drum to screw are prepared, and if this drum rotates, an advancing plate will displace in the direction of a cam-shaft axis. Fundamentally, although this drum is rotating with the hub, therefore is rotating with the advancing plate, if a brake force (damping force) is applied, rotational speed will fall temporarily and it will carry out relative rotation to an advancing plate. An advancing plate is made to carry out a variation rate in the direction of a cam-shaft axis by relative rotation of this drum, and the rotation phase of a cam shaft changes with them. in order to brake a drum here -- electromagnetism -- the braking member equipped with the coil prepares -- having -- electromagnetism -- when a coil energizes, a braking member carries out friction engagement at a drum end face, and the friction brake force brakes a drum. furthermore, a braking member -- electromagnetism -- the electromagnetic-brake force of a coil also brakes a drum.

[0006]

[Problem(s) to be Solved by the Invention] However, in the conventional electromagnetic adjustable valve timing equipment with which this braking member was prepared, there is a problem that wear of the friction engagement member (clutch) of a braking member is intense. For this reason, a brake force declines by wear of a friction engagement member, the time amount which the tooth lead angle of a cam shaft takes becomes long, or there is a problem that a tooth lead angle may become imperfect.

[0007] Then, invention-in-this-application persons did investigation and research detailed about the cause of wear of this friction engagement member, and acquired the following knowledge. namely, the case where the tooth lead angle of a cam shaft is started at time of day t1 in conventional electromagnetic adjustable valve timing equipment as shown in drawing 12 -- t1 -- electromagnetism -- operating potential is applied to a coil, by the braking member, a brake force is applied to a drum, in connection with this, the amount of tooth lead angles of a cam shaft increases gradually, reaches the amount of tooth lead angles predetermined by t2, and tooth-lead-angle actuation is completed. In addition, below, such a braking condition is called transient braking (at the time of transient braking). And in order to make

tooth-lead-angle actuation perform quickly at the time of this transient braking (t1-t2), operating potential is set up comparatively highly. However, since so big a brake force is not needed and a superfluous brake force serves as loss of engine power after reaching the predetermined amount of tooth lead angles (t2 or later), a brake force (operating potential) is lowered to the minimum needed for holding a predetermined tooth-lead-angle condition. In addition, below, this braking condition is called stationary braking (at the time of stationary braking), or maintenance (at the time of maintenance).

[0008] here -- electromagnetism -- although the electromagnetic-brake force and the friction brake force acted on the drum at the time of the energization to a coil, according to investigation and research of invention-in-this-application persons, the fact that wear of the friction engagement member of a braking member advanced mainly at the time of stationary braking became clear. That is, since the lubricating oil was supplied to the friction surface at the time of un-braking and this lubricating oil remains to the friction surface at the time of transient braking, wear of a friction engagement member is small. And it is a short time at the time of transient braking. On the other hand, since a lubricating oil is exhausted to a friction surface at the time of stationary braking, wear of a friction engagement member becomes intense. Moreover, stationary braking is comparatively crossed to long duration. In addition, becoming large has [the time when the friction brake force is larger] more natural wear of a friction engagement member.

[0009] If it strokes and the friction brake force will be reduced at the time of stationary braking, it will be thought that wear of a friction engagement member can be reduced. Here, the friction brake force and the electromagnetic-brake force of generally acting on a drum are expressed with the following formula 1 and a formula 2, respectively.

[Equation 1]

friction brake force = operating potential x coefficient-of-friction x peripheral velocity ..... a formula 1 –

[Equation 2]

Electromagnetic-brake force = operating potential x peripheral velocity .....

a formula 2

Correspondence of using an ingredient with small coefficient of friction for a friction engagement member, and reducing the friction brake force at the time of stationary braking from a formula 2, therefore a formula 1 can be

[0011]
[Means for Solving the Problem] Since the 1st invention attains the above-mentioned purpose based on the above-mentioned investigation and research result, and the above-mentioned consideration, The phase modification member which transmits the turning effort of a mechanical component to a cam shaft and to which the rotation phase of a cam shaft is changed with the variation rate to the predetermined direction on the other hand, The drum member to which the variation rate of the above-mentioned phase modification member is made to carry out in the above-mentioned predetermined direction according to the applied damping force, In the adjustable valve timing equipment of the engine with which the braking member which applies the friction-damping force and the electromagnetic-damping force to the above-mentioned drum member when a coil energizes was prepared electromagnetism -- a coil -- having -- this -- electromagnetism -- When the drum member is regularly braked by the braking member Rather than the time of braking transitionally after braking initiation, the adjustable valve timing equipment of the engine characterized by establishing a friction-damping force reduction means to reduce the ratio to the electromagnetic-damping force of the friction-damping force is offered.
[0012] The 2nd invention offers the adjustable valve timing equipment of the engine with which a friction-damping force reduction means is characterized by reducing the ratio to the electromagnetic-damping force of the friction-damping force by applying the force of an opposite direction to a braking member with a drum member side in the adjustable valve timing equipment of the engine concerning the 1st invention.
[0013] the elastic member to which a friction-damping force reduction means energizes a braking member to an opposite direction with a drum member side in the adjustable valve-timing equipment of the engine which the 3rd invention requires for the 2nd invention -- it is -- electromagnetism -- the decrement of the friction-damping force by the above-mentioned elastic member compensates with the electromagnetic-damping force at the time of the energization to a coil -- as -- electromagnetism -- the adjustable valve-timing equipment of the engine characterized by to be established the voltage-adjustment means which raises the electrical potential difference impressed to a coil offers.
[0014] In the adjustable valve timing equipment of the engine which the 4th invention requires for the 2nd invention It is a coil. the 2nd

electromagnetism which applies the electromagnetic force of an opposite direction to a braking member with a drum member side when a friction-damping force reduction means energizes -- this 2nd electromagnetism -- the adjustable valve timing equipment of the engine characterized by a coil energizing when the drum member is regularly braked by the braking member is offered.

[0015] In the adjustable valve timing equipment of the engine which the 5th invention requires for the 1st invention The 1st braking section arranged at the periphery side of an opposed face with a drum member at a braking member, Coefficient of friction of the 2nd braking section is set up smaller than coefficient of friction of the 1st braking section. the 2nd braking section arranged at the core side of the above-mentioned opposed face prepares -- having -- this -- And when a drum member is regularly braked by the 1st braking section, the adjustable valve timing equipment of the engine characterized by preparing the braking section operation system which operates the 2nd braking section is offered so that the 2nd braking section may apply damping force to a drum member.

[0016]

[Example]

The 1st example concerning the 1st, 2nd, and 3rd invention is explained below the <1st example>. As shown in drawing 1 , adjustable valve timing equipment CS 1 has the basic composition of transmitting the turning effort of the cam pulley 1 by which a rotation drive is carried out with a crankshaft (not shown) through a V belt (not shown) to the cam shaft 3 supported by bearing 2 free [rotation] through the tooth-lead-angle device V1. Below, for convenience, in drawing 1 , right-hand side is called "front", and left-hand side is called "back." In addition, a cam shaft 3 shall rotate counterclockwise here, in view of a before side.

[0017] The hub 6 of an approximate circle pilaster is attached in the front end section of a cam shaft 3 using the mounting screw 4 and the check pin 5. and the hub 6 -- the advancing plate 10 of an abbreviation ring form is arranged immediately at the before side at the centrum of the cam pulley 1. Two or more slot 10a for cam pulleys (one is illustrated) prolonged in the direction of a cam-shaft axis (drawing 1 longitudinal direction) and two or more slot 10b for hubs (one is illustrated) prolonged in the direction in which only the predetermined tilt angle inclined to the direction of a cam-shaft axis are formed in the periphery section of this advancing plate 10. Moreover, inside slot 10c which had an inclination in the inner skin of the advancing

plate 10 is formed. And cam pulley claw part 1a prolonged in the direction of a cam-shaft axis was prepared in the inner skin of the cam pulley 1, and this cam pulley claw part 1a has fitted in with slot 10a for cam pulleys of the advancing plate 10. Moreover, hub claw part 6a to which only the above-mentioned predetermined tilt angle inclines and extends to the direction of a hub axis was prepared in the periphery section of a hub 6, and this hub claw part 6a has fitted in with slot 10b for hubs of the advancing plate 10. In addition, the cam pulley 1 and the advancing plate 10 are equivalent to the "mechanical component" and the "phase modification member" which were indicated by claim 1, respectively.

[0018] Therefore, fundamentally, the cam pulley 1, the advancing plate 10, and a hub 6 (cam shaft 3) rotate in one. However, since slot 10b for hubs and hub claw part 6a have inclined and fitted in to the direction of a cam-shaft axis as aforementioned, if the advancing plate 10 displaces in the direction of a cam-shaft axis, the rotation phase to the cam pulley 1 of a hub 6 (cam shaft 3) will change. And in the 1st example, when the advancing plate 10 is located in the foremost part (imaginary line 10' shows), a cam shaft 3 carries out a lag most, and when located in the backmost part (a continuous line 10 shows), a tooth lead angle is carried out most. In addition, the rotation phase of a cam shaft 3 will be going to a hand of cut, and a tooth lead angle will be that the rotation phase of a cam shaft 3 shifts in the direction of a counterclockwise rotation, in view of a before side here, if it puts in another way.

[0019] In the front of a hub 6, the drum 7 of an approximate circle pilaster has been arranged further, sulcus-lateralis-cerebri section 7a which had an inclination in the periphery section of this drum 7 was formed in the centrum of the cam pulley 1, and inside slot 10c of the advancing plate 10 has fitted into this sulcus-lateralis-cerebri section 7a. Here, when a drum 7 carries out relative rotation clockwise to the advancing plate 10, in view of a before side, the advancing plate 10 displaces back and a cam shaft 3 carries out a tooth lead angle. In addition, a drum 7 is equivalent to the "drum member" indicated by claims 1-5.

[0020] And the drum 7 is connected with the stop plate 8 fixed to the hub 6 through the return spring 9. Here, while it is always energized in the direction of a counterclockwise rotation and the brake force (damping force) is not acting on a drum 7 with a return spring 9, in view of a before side, the drum 7 is rotated for the drum 7 by the maximum counterclockwise rotation to the point stopped by the tag (not shown). The advancing plate 10 is located

in the foremost part (lag location) in this condition. Here, if a brake force acts on a drum 7, a drum 7 resists the energization force of a return spring 9 according to a brake force, relative rotation will be clockwise carried out to the advancing plate 10, in view of a before side, the advancing plate 10 will displace back in connection with this, and a cam shaft 3 will carry out a tooth lead angle.

[0021] The braking member 14 of the approximate circle pilaster supported possible [displacement in the direction of a cam-shaft axis] by the fixed shaft 13 fixed to the cylinder head wall 12 is supported at the before [the front end side of a drum 7] side. And the braking member 14 is always energized ahead (cylinder head wall 12 side) by the coil spring 15. In addition, in order to prevent that the braking member 14 rotates to the circumference of a cam-shaft axis, the niting member 16 is formed. In addition, a coil spring 15 is equivalent to the "elastic member" indicated by the "friction-damping force reduction means" indicated by claims 1-3 thru/or claim 3. the friction engagement member 18 (clutch) with predetermined coefficient of friction attaches in the back end side of the shape of a ring of the braking member 14 -- having -- this friction engagement member 18 -- immediately -- a before side -- electromagnetism -- the coil 17 is arranged. and electromagnetism -- according to a braking condition, a predetermined electrical potential difference is impressed to a coil 17 by the power source and voltage adjustment means which are not illustrated. here -- electromagnetism -- while the coil 17 is not energizing, the braking member 14 and a drum 7 are not engaged, and a brake force is not applied to a drum 7, but the advancing plate 10 is located in the foremost part (lag location) at this time. on the other hand, electromagnetism -- the time of a coil 17 energizing -- electromagnetism -- according to the electromagnetic force (attraction) which acts between a coil 17 and a drum 7, the friction engagement member 18 is forced on the front end side of a drum 7, the friction engagement member 18 and a drum 7 carry out friction engagement, and the friction brake force is applied to a drum 7. further -- electromagnetism -- with a coil 17, the electromagnetic-brake force by electromagnetic-damping operation (eddy current) is applied to a drum 7. In this case, according to the magnitude of a brake force, a drum 7 is made to carry out relative rotation clockwise to the advancing plate 10, in view of a before side, and a cam shaft 3 carries out a tooth lead angle.

[0022] Actuation and the damping characteristic (tooth-lead-angle property) of each part at the time of braking a drum 7 and carrying out the tooth lead

angle of the cam shaft 3 in adjustable valve timing equipment CS 1, hereafter, are explained. For example, as shown in drawing 8 , when starting a tooth lead angle at time of day t1, operating potential is first set as the comparatively high predetermined electrical potential difference V1 by t1. By this, the electromagnetic-brake force and the friction brake force are applied to a drum 7 from the braking member 14, and the amount of tooth lead angles of a cam shaft 3 increases with time, and reaches the amount of tooth lead angles predetermined by t2 (the amount of the maximum tooth lead angles). Since the braking member 14 is ahead energized by the coil spring 15 at this time, the force which forces the friction engagement member 18 (braking member 14) on a drum 7 is reduced, and the friction brake force is reduced only for the part equivalent to this. The part which drew the slash in drawing 8 shows the friction brake force which decreased for the coil spring 15. In addition, a is a brake force (at the time of transient braking demand brake force) needed at the time of this transient braking. Thus, since the friction brake force decreases according to an operation of a coil spring 15, in order to compensate this decrement with the electromagnetic-brake force, operating potential V1 is raised a little compared with the operating potential V2 in conventional. In this case, in the conventional case, the ratios B1/A1 to the electromagnetic-brake force A1 of the friction brake force B1 become a little small compared with B'1 / A'1.

[0023] Operating potential is lowered after t2 to which the cam shaft 3 reached the predetermined amount of tooth lead angles to the predetermined electrical potential difference V3. V3 is set as an electrical potential difference from which the almost minimum brake-force b (at the time of maintenance demand brake force) needed in order to hold this tooth lead angle is obtained. The friction brake force is reduced like the time of transient braking (t1-t2) according to an operation of a coil spring 15 at the time of this stationary braking. However, at the time of stationary braking, since the original friction brake force (friction brake force in case there is no coil spring 15) is small compared with the time of transient braking, ratio B-2 to the electromagnetic-brake force A2 of friction brake force B-2 / A2 becomes very small (B-2/A2<B1/A1). here -- the above -- B-2 -- /-- A -- two -- the former -- adjustable -- valve timing -- equipment -- it can set -- friction brake -- the force -- electromagnetic brake -- the force -- receiving -- a ratio -- B -- one -- ' -- /-- A -- one -- ' -- or -- B-2 -- ' -- /-- A -- two -- ' -- large -- small -- becoming -- a thing -- being natural . In addition, in order to compensate the decrement of the friction brake force with the electromagnetic-brake force

also in this case, in the conventional case, operating potential V3 is raised a little from V4.

[0024] Thus, at the time of stationary braking, since friction brake force B-2 (or ratio B-2 / A2) becomes very small, wear of the friction engagement member 18 is reduced and the endurance of the braking member [1] 14 CS, i.e., adjustable valve timing equipment, is raised. In the example shown in drawing 8 , the full-service-braking force will be secured like the conventional case at the time of stationary braking (at the time of maintenance), and, as for friction brake force B-2, in the case of conventional adjustable valve timing equipment, only d will be reduced from B'2, and wear of the friction engagement member 18 will be reduced at this rate. As mentioned above, according to the 1st example, only by raising operating potential a little from the conventional case, securing a demand brake force, the friction brake force at the time of stationary braking (at the time of maintenance) can be reduced, and the endurance of the braking member 14 thru/or adjustable valve timing equipment CS 1 can be raised.

[0025] Although the 2nd example concerning the 1st, 2nd, and 4th invention is explained referring to drawing 2 below the <2nd example>, in order to avoid duplication of explanation, the same number as drawing 1 is attached about the 1st example shown in drawing 1 , and a common part, the explanation is omitted, and only a different point from the 1st example is explained. as shown in drawing 2 , positive electromagnetic force is given [in the braking member 14 of the 2nd example] to the braking member 14 through a bridgewall 20 at a before [a coil 17] side at the time of energization the 1st electromagnetism -- the coil 21 is formed the 2nd electromagnetism. In addition, in the 2nd example, a coil spring 15 (refer to drawing 1) like [in the case of the 1st example] is not formed.

[0026] And as shown, for example in drawing 9 , when starting a tooth lead angle at time of day t0, at the time of transient braking (t0-t1), only a coil 17 is energized the 1st electromagnetism (ON) and a coil 21 is not energized the 2nd electromagnetism (OFF). In this case, ratio C/D to the electromagnetic-brake force D of the friction brake force C is the same as that of the conventional case. on the other hand -- the time of stationary braking (t1-t2) -- both -- electromagnetism -- coils 17 and 21 energize. Since the force positive to the braking member 14 is given by the coil 21 the 2nd electromagnetism at this time, the friction brake force C (or ratio C/D) is reduced only at this rate, therefore wear of the friction engagement member 18 is reduced, and the endurance of the braking member 14, i.e., the

endurance of adjustable valve timing equipment CS 2, is raised. the 2nd example -- the 1st -- the 2nd electromagnetism, coils 17 and 21 are only turned on and off on a predetermined electrical potential difference, it is with the time of transient braking and stationary braking, and especially the electrical-potential-difference change of a coil 17 is not performed the 1st electromagnetism. For this reason, the electromagnetic-brake force at the time of transient braking and stationary braking becomes equal. In the example shown in drawing 9 , the friction brake force at the time of stationary braking is f1, and is very small compared with the friction brake force f2 in conventional. As mentioned above, also in the 2nd example, securing a demand brake force, like the 1st example, the friction brake force at the time of stationary braking (at the time of maintenance) can be reduced, and the endurance of the braking member 14 thru/or adjustable valve timing equipment CS 2 can be raised.

[0027] Although the 3rd example concerning the 1st and 5th invention is explained referring to drawing 3 - drawing 5 below the <3rd example>, in order to avoid duplication of explanation, the same number as drawing 1 is attached about the 1st example shown in drawing 1 , and a common part, the explanation is omitted, and only a different point from the 1st example is explained. As shown in drawing 3 - drawing 5 , in the 3rd example, the piston 33 which the crevice 31 of the configuration which will become annular seen from back if the configuration which will present an annular cross section if it cuts into the part of approach at the flat surface which intersects perpendicularly with a cam-shaft axis puts in another way was formed, and was equipped with the brake ring 32 (friction engagement member) in this crevice 31 among the braking members 14 is inserted. And the brake ring 32 is formed here where the heater room 35 is established in the circumference of a crevice 31 here [near the part with which it filled up with the wax in the front crevice 31 from the piston 33, and this wax was filled up], and the electric heater 36 (heating wire) is arranged in this heater room 35 with the ingredient high [of abrasion resistance] smaller [coefficient of friction] than the friction engagement member 18 of the body section of the braking member 14. In addition, from a crevice 31, the friction engagement member 18 by the side of a periphery is equivalent to "the 1st braking section" indicated by claim 5, and the brake ring 32 is equivalent to "the 2nd braking section" indicated by claim 5. Moreover, a piston 33 and electric heater 36 grade are equivalent to the "braking section operation system" indicated by claim 5. Here, drawing 3 , drawing 4 , and drawing 5

show the condition at the time of stationary braking (except for the first stage) the first stage at the time of transient braking thru/or stationary braking at the time of un-braking, respectively.

[0028] A tooth-lead-angle property thru/or a damping characteristic in case a tooth lead angle is started at time of day t0 by drawing 10 is shown. In addition, in drawing 10 , t0-t1, and t1-t2 are actual very short time amount. the time of day t0 or before -- electromagnetism -- a coil 17 and an electric heater 36 do not energize, but adjustable valve timing equipment CS 3 is in the condition which shows in drawing 3 . At this time, a brake force is not applied to a drum 7 from the braking member 14, therefore a cam shaft 3 is in the condition of having carried out the lag most. and the time of day t0 -- electromagnetism -- a coil 17 and an electric heater 36 energize on a comparatively high predetermined electrical potential difference. here -- electromagnetism -- by energization to a coil 17, the braking member 14 displaces only x0 back, and the friction engagement member 18 carries out friction engagement with the front end side of a drum 7. At this time, the friction brake force and the electromagnetic-brake force are applied to a drum 7, it will be in a transient braking condition, and the amount of tooth lead angles of a cam shaft 3 will increase with time. Moreover, by energization to an electric heater 36, the wax in a crevice 31 expands and a piston 33 and the brake ring 32 displace back gradually in a crevice 31 in connection with this. The ratios B1/A1 of the friction brake force B1 in this condition which receive electromagnetic-brake force A1 are the same as that of the case of conventional adjustable valve timing equipment almost.

[0029] next, the time of the amount theta of tooth lead angles (cam angle theta) reaching the amount theta 0 of the maximum tooth lead angles -- t1 -- electromagnetism -- the electrical potential difference applied to the coil 17 and the electric heater 36 is lowered to a predetermined value, respectively. That is, since it changed into the stationary braking condition, in order to reduce power loss, the brake force to a drum 7 is reduced to necessary minimum. Although the amount of displacement to the back of the brake ring 32 is x1 at this t1 time, the brake ring 32 has not reached the back end side of the braking member 14 yet. In addition, drawing 4 shows the condition in the time of the amount theta of tooth lead angles reaching the amount theta 0 of the maximum tooth lead angles. the time of t2 [32], i.e., the brake ring, carrying out friction engagement with a drum 7 the time of the brake ring 32 reaching the back end side of the braking member 14 after t1 -- t2 ****** -- electromagnetism -- since the operating potential of a coil 17

is lowered, although the full-service-braking force declines, B-2 / A2 of the ratio to the electromagnetic-brake force A2 of friction brake force B-2 are almost the same as that of the ratios B1/A1 in t0-t1. In addition, since the energization to an electric heater 36 is continued, the wax in a crevice 31 continues expanding and the brake ring 32 displaces back gradually. And the brake ring 32 contacts the front end side of a drum 7 at time of day t2, after this, the brake ring 32 and the friction engagement member 18 carry out friction engagement with both the front end sides of a drum 7, and adjustable valve timing equipment CS 3 will be in the condition which shows in drawing 5 .

[0030] Generally, the friction brake force is proportional to the product of the peripheral speed of a friction engagement part, coefficient of friction, and a load. And since the brake ring 32 (a kind of a friction engagement member) and the friction engagement member 18 carry out friction engagement of after [both] t2 with a drum 7, rather than the time (t1-t2) of only the friction engagement member 18 carrying out friction engagement with a drum 7, the average radius as the whole friction engagement part becomes small, and, for this reason, the average peripheral speed as the whole friction engagement part becomes small. Furthermore, since the brake ring 32 is formed with the ingredient with coefficient of friction smaller than the friction engagement member 18 as described above, average coefficient of friction as the whole friction engagement part also becomes small. In addition, by friction engagement to the drum 7 of the brake ring 32, although the friction engagement area as the whole friction engagement part increases, the friction brake force is not directly connected with friction engagement area. For this reason, after t2, rather than t1-t2, the friction brake force B3 becomes small, and ratio B3-/A3 to electromagnetic-brake force A3 of the friction brake force B3 becomes smaller than B-2 / A2 thru/or B1/A1. Therefore, wear of the friction engagement member 18 is reduced and the endurance of adjustable valve timing equipment CS 3 is raised. In addition, since the brake ring 32 is formed with the wear-resistant high ingredient, it hardly rubs. Moreover, the friction engagement area as the whole friction engagement part becomes large rather than t1-t2 after t2. However, since a load is equal, the planar pressure of a friction engagement side becomes small, and wear of the friction engagement member 18 is reduced further. In addition, since the brake ring 32 is formed with the wear-resistant high ingredient, of course, the abrasion resistance as the whole friction engagement part is raised by this.

[0031] As shown in drawing 6 , the variation rate of the piston 33 is not carried out by expansion and contraction of a wax, and the crevice 31 by the side of a front [piston / 33] is connected to the oil pressure device 42 (hydraulic pump) through the hydraulic-pressure-supply path 41, and it may be made to carry out the variation rate of the piston 33 by the feeding and discarding of the oil pressure to a crevice 31. In this case, if oil pressure is supplied to a crevice 31 from the oil pressure device 42 at time of day t2 as shown in drawing 11 , the almost same tooth-lead-angle property thru/or damping characteristic as a case of the adjustable valve timing equipment CS 3 shown in drawing 3 - drawing 5 will be acquired. moreover, it is shown in drawing 7 -- as -- the object for pistons -- electromagnetism -- it may be made to carry out the variation rate of the piston 33 according to the electromagnetic force using a coil 45. in this case, t2 time in drawing 11 -- electromagnetism -- what is necessary is to energize in a coil 45 and just to make a drum 7 carry out friction engagement of the brake ring 32 As mentioned above, also in the 3rd example, securing a demand brake force, the friction brake force at the time of stationary braking (at the time of maintenance) can be reduced, and the endurance of the braking member 14 thru/or adjustable valve timing equipment CS 3 can be raised.

[0032]

[Function and Effect of the Invention] According to the 1st invention, since the ratio to the electromagnetic-damping force of the friction-damping force is lowered by the friction-damping force reduction means at the time of stationary braking of a drum member (at the time of maintenance), the friction-damping force can be reduced, holding required damping force. For this reason, wear of a braking member is reduced and the endurance of adjustable valve timing equipment is raised.

[0033] According to the 2nd invention, the same operation and effectiveness as the 1st invention are acquired fundamentally. Furthermore, since the friction-damping force is reduced only by applying the force of an opposite direction to a braking member with a drum member side at the time of stationary braking (at the time of maintenance), the configuration of a friction-damping force reduction means will become simple.

[0034] According to the 3rd invention, the same operation and effectiveness as the 2nd invention are acquired fundamentally. Furthermore, the friction-damping force is reduced to a braking member with the easy configuration which prepares elastic members, such as a spring.

[0035] According to the 4th invention, the same operation and effectiveness

as the 2nd invention are acquired fundamentally. furthermore, a braking member -- the 2nd electromagnetism -- the friction-damping force is reduced with the easy configuration which prepares a coil.

[0036] According to the 5th invention, the same operation and effectiveness as the 1st invention are acquired fundamentally. Furthermore, since the peripheral speed and coefficient of friction as the whole friction engagement part are reduced by friction engagement of the 2nd braking section and a drum member at the time of stationary braking, wear damping force can be reduced securing required damping force, wear of a braking member is reduced, and the endurance of adjustable valve timing equipment is raised.

[Brief Description of the Drawings]

[Drawing 1] It is the side-face cross-section explanatory view of the adjustable valve timing equipment in which the 1st example of this invention is shown.

[Drawing 2] It is the side-face cross-section explanatory view of the adjustable valve timing equipment in which the 2nd example of this invention is shown.

[Drawing 3] It is the side-face cross-section explanatory view of the adjustable valve timing equipment in which the 3rd example of this invention is shown.

[Drawing 4] It is the side-face cross-section explanatory view of the adjustable valve timing equipment shown in drawing 3 , and the condition in the first stage is shown at the time of transient braking thru/or stationary braking.

[Drawing 5] It is the side-face cross-section explanatory view of the adjustable valve timing equipment shown in drawing 3 , and the operating state at the time of stationary braking (except for the first stage) is shown.

[Drawing 6] It is the side-face cross-section explanatory view of the braking member to which it was made to carry out the variation rate of the piston with oil pressure.

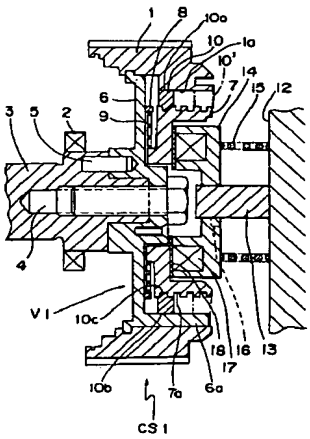
[Drawing 7] a piston -- electromagnetism -- it is the side-face cross-section explanatory view of the braking member which was made to carry out a variation rate with a coil.

[Drawing 8] It is drawing showing the property over the time amount of the amount of cam-shaft tooth lead angles and operating potential in the 1st example, and a brake force.

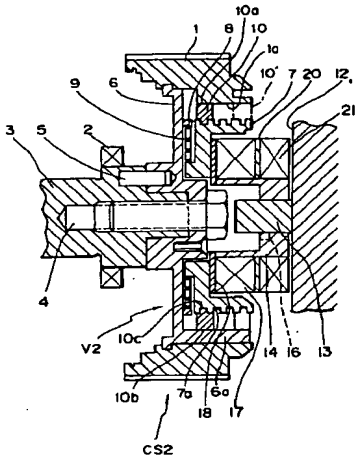
[Drawing 9] It is the brake force, the 1st, and drawing showing the property of as opposed to the time amount of the on-off condition of a coil the 2nd

electromagnetism in the 2nd example.
[Drawing 10] It is drawing showing the property over the time amount of the tooth-lead-angle property in the 3rd example thru/or a damping characteristic.
[Drawing 11] It is drawing showing the property over the time amount of the tooth-lead-angle property thru/or damping characteristic of the adjustable valve timing equipment to which it was made to carry out the variation rate of the piston with oil pressure.
[Drawing 12] It is drawing showing the property that the time amount of the tooth-lead-angle property of conventional electromagnetic adjustable valve timing equipment thru/or a damping characteristic receives.
[Description of Notations]
CS1, CS2, CS3 -- Adjustable valve timing equipment
V1, V2, V3 -- Tooth-lead-angle device
1 -- Cam pulley
3 -- Cam shaft
7 -- Drum
10 -- Advancing plate
14 -- Braking member
15 -- Coil spring
17 -- electromagnetism -- a coil
18 -- Friction engagement member
20 -- It is a coil the 2nd electromagnetism.
31 -- Crevice --
32 -- Brake ring
33 -- Piston
36 -- Electric heater
42 -- Oil pressure device
the object for 45 -- pistons -- electromagnetism -- a coil

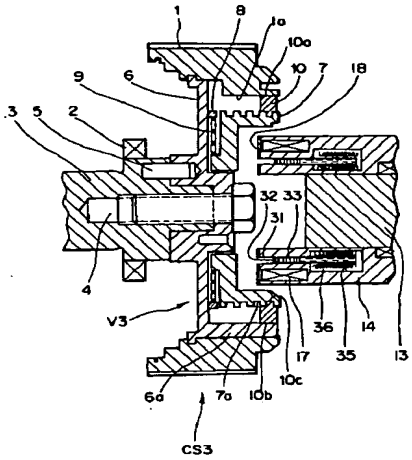
[Drawing 1]



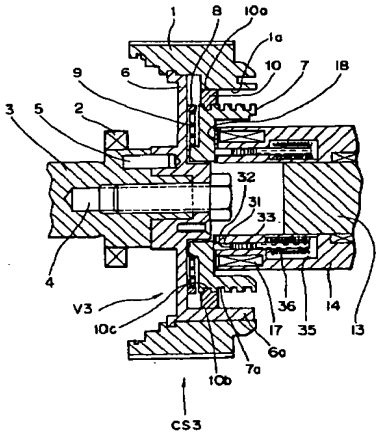
[Drawing 2]



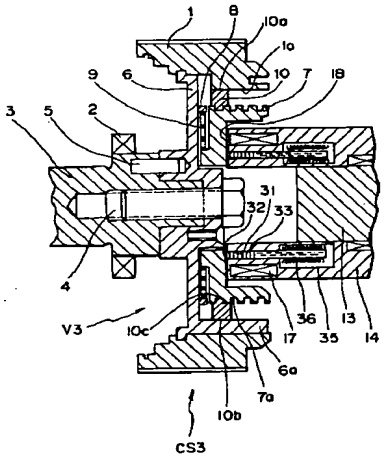
[Drawing 3]



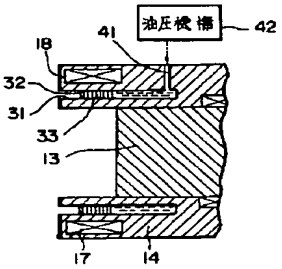
[Drawing 4]



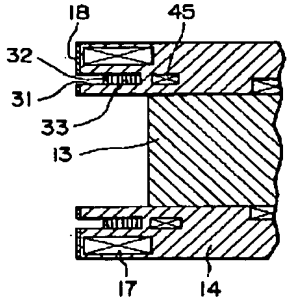
[Drawing 5]



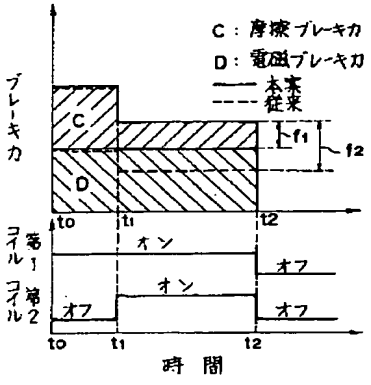
[Drawing 6]



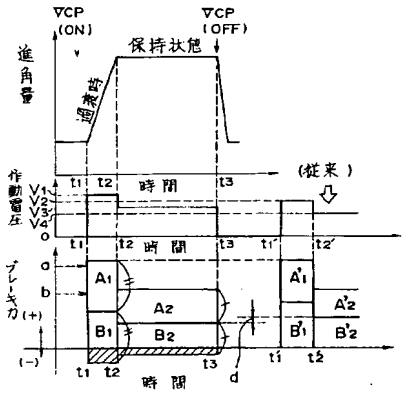
[Drawing 7]



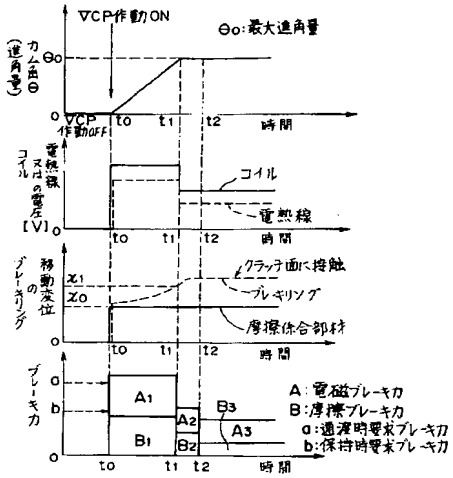
[Drawing 9]



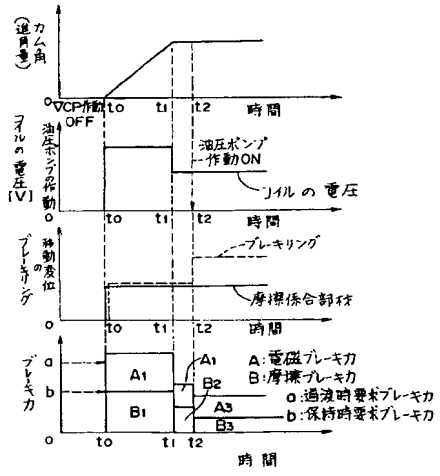
[Drawing 8]



[Drawing 10]



[Drawing 11]



[Drawing 12]